THE HISTORY AND DEVELOPMENT OF WRC TRANSMITTER

By

Wilbur M. Herbert

November 17, 1939

THE HISTORY AND DEVELOPMENT OF WRC TRANSMITTER

The new WRC transmitter was built and placed into operation after definite evidence had been obtained showing that a new set up was necessary. The selection of a site was an important problem to solve, and the choice of the most desirable power had to be considered. Construction and erection of antenna and ground system was next considered. The transmitter proper is a complicated piece of equipment and discussion was limited. The acquisition of power, emergency facilities, and antenna-transmitter coupling were described. The final consideration was the completion of the transmitter and the results of test performed.

On March 15, 1938 WRC silenced forever the old transmitter which had faithfully and continuously served the Nation's Capital for fifteen years, and replaced it with a new transmitter. Washington's newest and most modern transmitter is located approximately six miles northeast of the capital in Chillum, Maryland.

WRC selected a new transmitter site because the station desired to provide better service to the majority of its listeners, by moving to a more suitable location. They desired to increase the power and found it was necessary to relocate in order that excessive blanketing did not occur.

SELECTION OF SITE

Considering the magnitude of the investment and the possible cost and inconvenience of moving to a more suitable site at some future time the selection of a new location became of great importance. Therefore, the engineers looked for a site which would stand up under the following requirements: (1) The site must be so situated that blanketing of an excessive percentage of receivers will not be produced. (2) The site should be so located with respect to the service area that a suitable directive antenna will furnish the desired protection, if this protection is necessary, without undue limitation of the service area. (3) The site should provide a maximum signal for the greatest possible number of listeners. The city immediately adjacent to the station should receive not less than approximately 50 millivolts per meter to insure good service under adverse noise and atmospheric disturbances. (4) The site should preferably be near established power and telephone facilities. (5) The site should be located on terrain that permits good efficiency from the antenna system. This means, under ideal conditions, level marshy land. (6) The site should be near a

main highway in order that it be accessible under adverse weather conditions. (7) There should be available, at reasonable cost, a sufficient area of land to accommodate the antenna and ground system. (8) The antenna system should not be an undue hazard to established airlines.

After consideration of the above requirements the possible sites were selected, and on the one seeming most promising a test transmitter and antenna were placed. This test transmitter is generally a low-power portable or semi-portable transmitter, capable of delivering about 100 watts into the antenna with good frequency, stability, and little fluctuation of output power. The antenna may be any conveniently erected vertical antenna. Usually in order to facilitate loading and to reduce loading losses, it should be preferably of cage type. The signals sent out from this test outfit were picked up by an automobile radio, this was done at night. The data was compiled from tests, the selection of the site being governed by the results.

On the basis of these tests a site was chosen at Chillum, Maryland. These tests showed that listeners in the District of Columbia, Virginia, and Maryland would be provided with a new high in fidelity of transmission and absence of noise.

THE TERRAIN

Interesting results were obtained when wash borings were examined as a guide to foundation design. The area on which this station is built was once a valley, the floor of which was 30 feet below the existing ground level. The borings indicated unusually interesting soil strata, not the least of which was a layer of decayed wood and vegetation. The wood was in a fair state of preservation although having been buried for thousands of years. From a depth of only 12 feet in one of

BUILDING

the guy anchor excavations, decayed wood was found which was in an advanced stage of turning to coal.

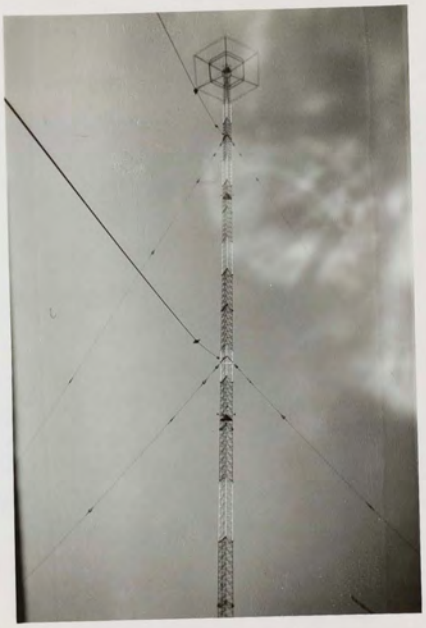
Although the soil strata was unusual, and swampy terrain of the type encountered makes possible efficient radio transmission, it provides conspicuously poor foundation conditions for antennas and buildings. As a result, the guy anchors, tower, and buildings are supported on 30 foot wood and concrete piles. The building, antenna pier and guy anchors are, in addition, built several feet above the maximum recorded flood water level. Since the station has nothing to fear from floods, and ground conditions are improved by them, the station staff are prepared to accept them with equanimity if not enthusiasm.

ANTENNA

The new antenna is of uniform cross section from top to bottom, and is triangular in shape, with faces five feet wide. At the top of this slender, but strong structure there is a steel capacity top 50 feet in diameter. This so called "high hat" is the top tuning structure which NBC had pioneered at KOA in 1933, WPTF and WHIO in 1934, and WMAQ in 1935. It has been developed to a high state of effectiveness.

Although it is usually desirable to erect an antenna to the optimum height, restrictions are frequently imposed by the United States Department of Aeronautics and the Federal Communication Commission, which make it necessary to resort to other expedients in order to obtain satisfactory efficiency. This occured in the case of WRC. The 50 foot diameter steel top, used in connection with the authorized height of 400 feet, made it possible to approach the desired results without supplementary insulation and inductance loading at the top of the structure.

The specifications for the WRC vertical radiator or antenna



MAIN ANTENNA

AUXILIARY ANTENNA

insured not only high electrical efficiency, but also greater mechanical strength than is customary. As a result of investigation of wind velocity distribution at various heights above the earth the antenna was built to withstand an indicated wind velocity of 120 miles per hour at the top and approximately 95 miles per hour at the bottom. The tower was constructed of solid rounds electrically welded together into sections 22 feet long. These sections were fabricated in the steel mill and assembled by means of butt flanges in the field. As specified for all NBC towers, the complete guy wire and insulator system was assembled and stressed up to specified stress conditions in a suitably equipped testing plant. This eliminated any possibility of unsuspected weaknesses and also increases the modulus of elasticity of the guy cable. The use of track bonds around bolted joint insured satisfactory electrical connections. At the bottom is a horn gap for discharging lightning.

The ground system for this new structure consists of 66,000 feet of copper ribbon buried in the swamp beneath it. The strop was buried ten inches below the surface and was laid in position by means of a special plow which automatically raised a furrow, guided the ribbon into position beneath it, and partially covered it. The special plow has been developed by NBC for this purpose. It is a modified "sub-soiler" which was adapted for the purpose after experimentation with other types. A mounting was provided on which a reel of copper ribbon could be quickly attached and the end of the ribbon guided to a roller at the rear of the plow point through which it was deposited at the bottom of the furrow. The special plow or "sub-soiler" may be adjusted for any depth of furrow desired. A tractor, preferably equipped with a bull-dozer, completes the equipment. The bull-dozer smooths up the

ground after the work is completed, fills in brooks and ditches by brute force, and moves logs, rocks, etc. With an energetic crew, over 6,000 feet of ribbon can be buried accurately and uniformly per day.

TRANSMITTER

The new WRC transmitter is the RCA type 5D, which contains facilities for changing power from one kilowatt for night broadcast to five kilowatts for day operation by means of relays. The transmitter is of the most recent design, and consists of seven units. There are four main panel units, that is, the exciter unit, the power-amplifier unit, the modulator-rectifier unit, and the control unit, and the three auxiliary units consisting of the filter racks, the modulation transformer-reactor assembly, and the main plate tranformer.

The transmitter is of vertical chassis design and contains high power tubes which do not require water cooling apparatus and radiators, formerly a necessary nuisance in intermediate powered stations. These tubes are cooled by means of low speed fans which make no perceptible sound. The absence of noise from blowers, contactors, and other transmitter parts make possible high fidelity monitoring immediately adjacent to the transmitter.

The transmitter features improved class B modulation in which the idle plate current is less than 400 ~~watts~~ mil-amps. The idle modulator plate current can be reduced to zero by a simple adjustment, with an increase of less than 1% in harmonic distortion. This system makes possible a very large increase in economy because the power consumed by the modulator is confined to filament lighting during periods of zero modulation. The total power consumed by the new transmitter is only 16 kilowatts during normal modulation, a reduction of about 50% from

INTERIOR OF BUILDING SHOWING LAYOUT OF TRANSMITTER

FILTER RACK AND MAIN PLATE TRANSFORMER

Vertical chassis construction makes for maximum accessibility. Rear view of power amplifier and modulator units.

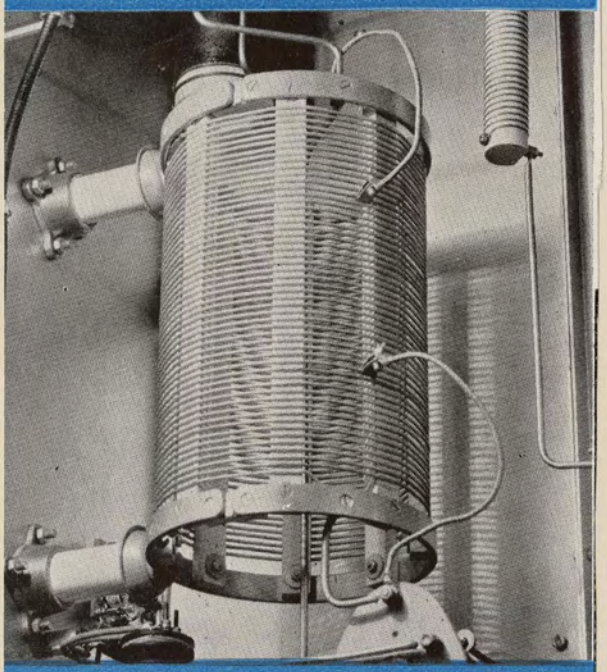
older designs of 5 kilowatt stations.

The audio frequency system up to and including the modulators is practically all resistance coupled to reduce phase shift. This makes possible an unusually simple and effective reversed feedback system which reduces harmonic distortion and background noise to extremely low values. One of the most attractive features about this feedback system is its utter simplicity. There are no rectifier tubes, amplifiers, or other parts to wear out or require replacement. As reference to the schematic circuit diagram, this feedback system operates from the primary of the modulation transformer to the secondary of the audio input transformer. The feedback system is a simple, permanently fixed resistive network.

The radio frequency system utilizes duplicate low temperature coefficient quartz crystals with trimmers, by which it is possible to quickly and easily adjust the transmitter to be exactly on its frequency. The transmitting frequency is 950 kilocycles and never varies more than 10 cycles.

Adjacent to transmitter proper is the speech input equipment. The two separate telephone lines running from the studio are terminated in this piece of equipment. The speech input equipment supplies the drop that occurs on the telephone lines and then passes signal to transmitter. The volume control unit is automatic and all circuits contain automatic circuit breakers. The speech input equipment is made in duplicate and contains a means of locating trouble in case of signal failure. Mounted with this equipment is a beat frequency meter and clocks to register the time the station is off the air during scheduled broadcast.

Top: Duplicate crystal oscillators, with V-cut "zero" temperature coefficient crystals, are provided.



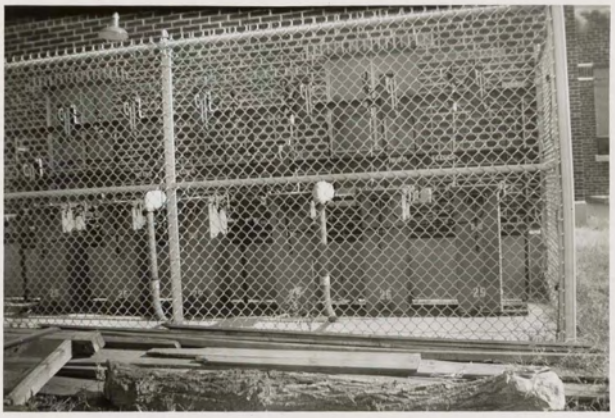
Above and right: Note clean-cut, well-designed components.

POWER SUPPLY

The station power supply is provided in duplicate, incorporating separate buried armored cables, transformer and metering equipment, terminating in a fully automatic switch which instantly changes power lines in the event of a failure. The power lines are from Baltimore and Washington, D.C. The voltage is 230 volts, three phase, 60 cycles with a power factor of approximately 90%. The efficiency of the transmitter is such that 7.15 kilowatt input is required for 5 kilowatt output and 1.43 kilowatt input is required for 1 kilowatt output. The automatic switch operates when any one of the three phases fails, and will change from one line to the other so rapidly that the program is not interrupted, thus providing better protection against such failures than could be obtained by manual operation.

GENERAL EQUIPMENT

WRC was equipped with an RCA type 69A distortion meter and type 68A audio oscillator. With this combination of instruments the percentage of distortion at any frequency within the transmitter range may be measured quickly and accurately and the background noise level may be measured with equal facility. To facilitate transmitter testing off the air the station was provided with a simple dummy antenna consisting of Ohm spun resistor units connected to simulate the characteristic of the coaxial transmission line. The transmitter has a waterproof antenna-coaxial line coupling unit, together with the monitoring rectifier. This monitoring rectifier provides the ideal means of operating a remote reading antenna meter since it is impervious to lightning discharges which would easily burn out a thermocouple. It also supplies



DUPLICATE 3 PHASE POWER SUPPLY TRANSFORMER

the excitation for a relay which removes power in case of an arc across the antenna base following a lightning discharge, or in case carrier power is lost for any other reason.

To be used in case of emergency is a small antenna approximately 100 feet high, and containing all necessary equipment for operation. This antenna would reduce the loss in profit due to failure of a commercial broadcast to a figure less than $100. This auxiliary antenna operates on one fifth the wave.

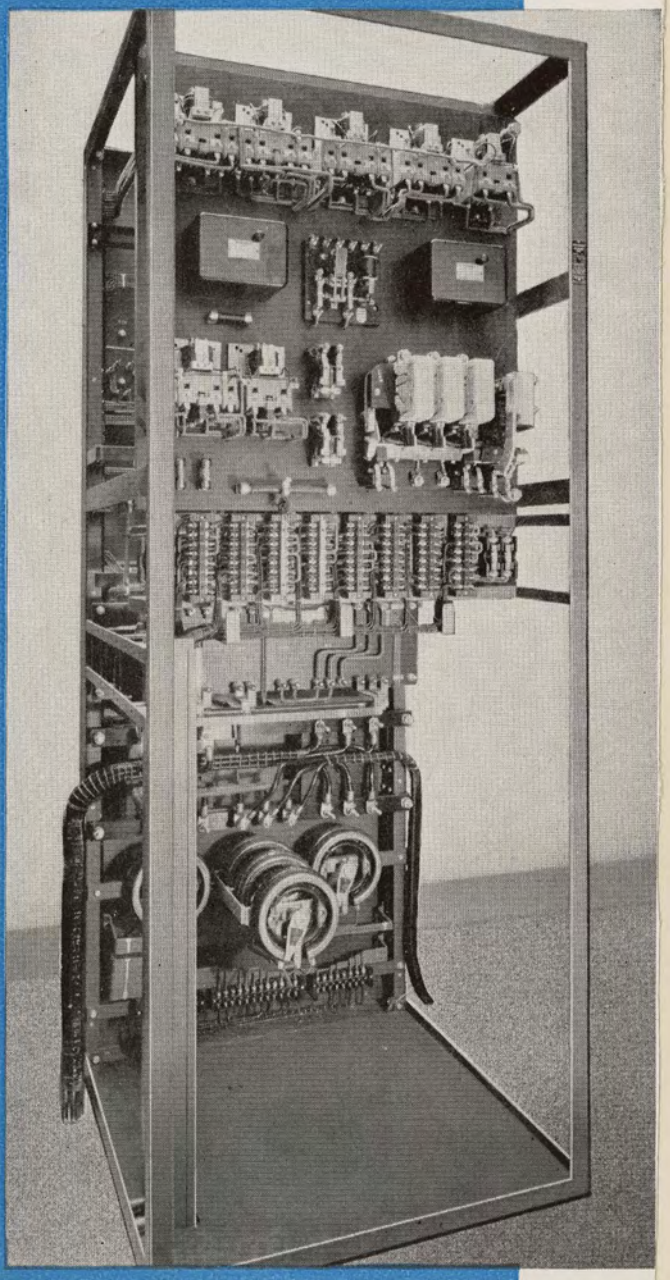
The transmission line which connects the radio transmitter with the antenna is a two inch coaxial system, using a new type of insulator which raised the breakdown voltage by 300%. The line is buried a minimum of three feet in the earth. One of the final operations on the line consisted of closing small gas leaks caused by minute blow holes in the casting. Such leaks could not be detected by any practical method except immersion in clean water. The line maintained 40 pounds pressure, with no loss for three days, before it was finally placed into position and covered. At the end of the next five weeks there was still no noticeable loss so the pressure was reduced to 20 pounds. A section of this line, with the new insulators, was tested before installation for voltage breakdown and heating. The heat run was made at a radio frequency voltage equivalent to that which would be obtained with a transmitter power of 2,000 kilowatts. In final position the line rests on planks and is protected by split tile.

CONCLUSION

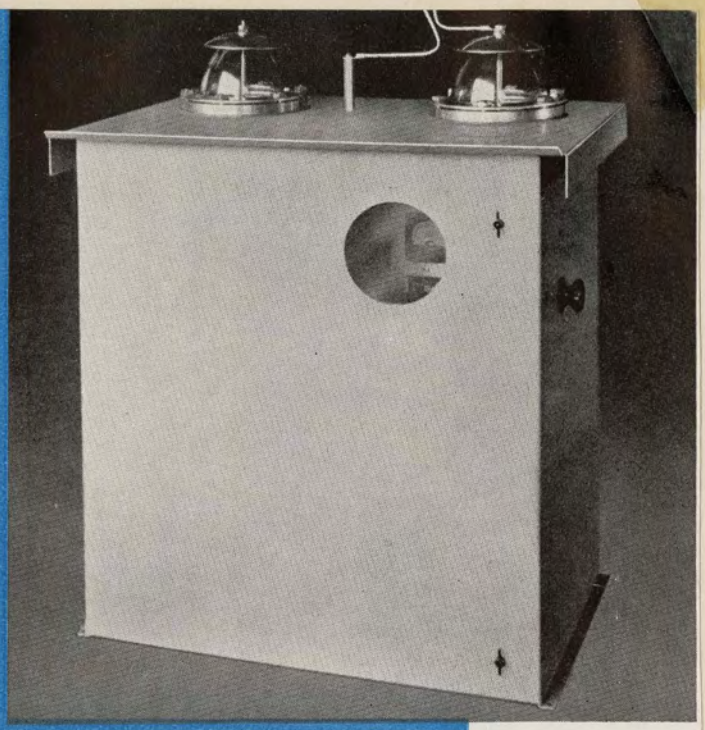
The field intensity survey of the new WRC station was made as soon as it was placed in operation. The measurements showed that the results expectd were slightly exceeded, and that WRC excels in providing

service in the District of Columbia and its environs.

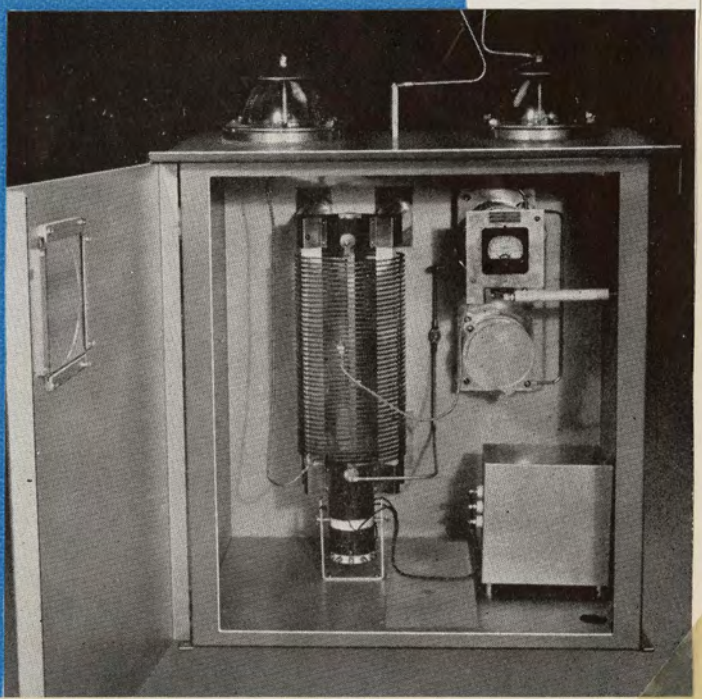
The RCA Metal Anode Air-Cooled Tubes are standard, long-life tubes provided with a copper fin mounting.

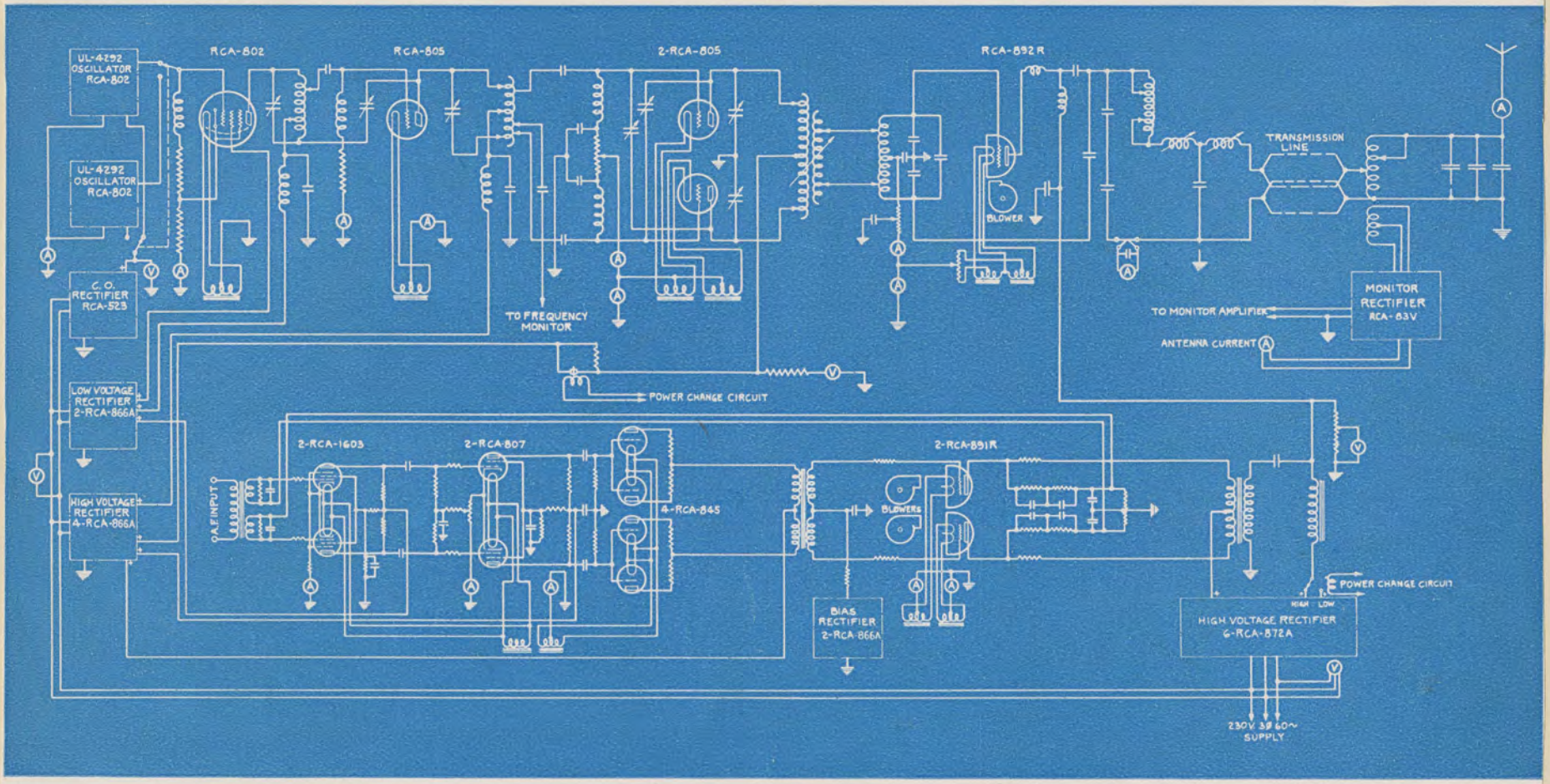


Rear view of the power control unit. Relays, contactors, breakers and rheostats are segregated from the radio circuits.



Interior and exterior views of the antenna coupling unit. Note weatherproof cabinet.





SIMPLIFIED SCHEMATIC CIRCUIT DIAGRAM OF THE 5-D TRANSMITTER

BIBLIOGRAPHY

C. L. Beach
Engineering Sales
RCA Manufacturing Company

J. G. Rogers
Transmitter Engineer WRC

RCA Review
April 1938, Vol. II, number 4
January 1939, Vol. III, number 3
April 1939, Vol. III, number 4

A. T. E. Journal
July-1938